Association between socioeconomic deprivation and surgical complications in adults undergoing ankle fracture fixation: a population-based analysis

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Background: Few studies have investigated the outcomes of surgical fracture care among socially deprived patients despite the increased incidence of fractures and the inequality of care received in this group. We evaluated whether socioeconomic deprivation affected the complications and subsequent management of marginalized/homeless patients following surgery for ankle fracture.

Methods: In this retrospective, population-based cohort study involving 202 hospitals in Ontario, Canada, we evaluated 45 444 patients who underwent open reduction and internal fixation (ORIF) for ankle fracture performed by 710 different surgeons between Jan. 1, 1994, and Dec. 31, 2011. Multivariable logistic regression models were used to assess the association between deprivation and shorter-term outcomes within 1 year (implant removal, repeat ORIF, irrigation and débridement owing to infection, and amputation). Multivariable Cox proportional hazards models were used to assess longer-term outcomes up to 20 years (ankle fusion and ankle arthroplasty).

Results: A higher level of deprivation was associated with an increased risk of irrigation and débridement (quintile 5 v. quintile 1: odds ratio [OR] 2.14, 95% confidence interval [CI] 1.25–3.67, $p = 0.0054$) and amputation (quintile 4 v. quintile 1: OR 3.56, 95% CI 1.01–12.4, $p = 0.0466$). It was more common for less deprived patients to have their hardware removed (quintile 5 v. quintile 1: OR 0.822, 95% CI 0.76–0.888, $p < 0.0001$). There was no correlation between marginalization and subsequent revision ORIF, ankle fusion, or ankle arthroplasty.

Conclusion: Marginalized patients are at a significantly increased risk of infection and amputation following surgical treatment of ankle fractures. However, these complications are still extremely uncommon among this group. Socioeconomic deprivation should not prohibit marginalized patients from receiving surgery for unstable ankle fractures.

Contexte : Malgré l'incidence accrue des fractures et les inégalités dans la prestation des soins chez les patients au statut socio-économique précaire, peu d'études se sont penchées sur les résultats de la chirurgie pour fracture chez cette population. Nous avons voulu vérifier si une situation socio-économique précaire influait sur les complications et la prise en charge subséquente des patients marginalisés/itinérants après une chirurgie pour fracture de la cheville.

Méthodes : Au cours de cette étude de cohorte rétrospective basée dans la population regroupant 202 hôpitaux en Ontario, au Canada, nous avons évalué 45 444 patients ayant subi une réduction ouverte avec fixation interne (ROFI) pour fracture de la cheville, effectuée par 710 chirurgiens différents entre le 1er janvier 1994 et le 31 décembre 2011. Des modèles de régression logistique multivariée ont servi à évaluer le lien entre le statut précaire et les résultats à court terme (au cours de l'année) (retrait de l'implant, réintervention pour ROFI, irrigation et débridement en raison d'une infection, et amputation). Des modèles d'analyse multivariée à risques proportionnels de Cox ont servi à évaluer les résultats à plus long terme, jusqu'à 20 ans (fusion de la cheville et arthroplastie de la cheville).

Résultats : Le risque d'irrigation et débridement (quintile 5 c. quintile 1 : rapport des cotes [RC] 2,14, intervalle de confiance [IC] de 95 % 1,25–3,67, $p = 0,0054$) et d'amputation (quintile 4 c. quintile 1 : RC 3,56, IC de 95 % 1,01–12,4, $p = 0,0466$) était proportionnel à la précarité de la situation des individus. Les patients moins défavorisés étaient moins susceptibles de se faire retirer leurs implants (quintile 5 c. quintile 1 : RC 0,822, IC de 95 % 0,76–0,888, $p < 0,0001$). On n'a observé aucune corrélation entre la marginalisation et une réintervention pour ROFI, fusion de la cheville ou arthroplastie de la cheville.

Conclusion : Les patients marginalisés sont exposés à un risque significativement plus élevé d'infection et d'amputation après un traitement chirurgical pour fracture de la cheville. Cependant, de telles complications demeurent extrêmement rares chez cette population. Un statut socioéconomique précaire ne devrait pas empêcher les patients marginalisés de recevoir une chirurgie lors de fractures instables de la cheville.

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Socially deprived patients face important barriers that reduce their access to care, presenting unique challenges for orthopedic surgeons.[1] These patients experience unique health conditions, and disease severity is high because of factors including extreme poverty, delays in seeking care, nonadherence to therapy, mental health and substance abuse issues, and the adverse health effects of homelessness.[1,2] Socially deprived patients are more likely to obtain their care in the emergency department than in an outpatient clinic.[3] This is a substantial challenge for delivering efficient, cost-effective and patient-centred care.

Few studies have investigated the outcomes of surgical fracture care among socially deprived patients[4–6] despite the increased incidence of fractures[4] and the inequality of care received in this group. For example, Perry and colleagues[7] found inequalities in the use of total hip arthroplasty for displaced intracapsular hip fractures in patients with higher levels of socioeconomic deprivation.

We studied a large population-based cohort of patients with ankle fracture to evaluate whether social deprivation affected the complications and subsequent management of marginalized or homeless patients following surgery for ankle fracture.

Methods

Data sources and setting

This was a population-based cohort study. Data were obtained from several health administrative databases reflecting patient encounters from 202 hospitals in Ontario, Canada. These databases are held securely in linked, encoded form, and data were analyzed at ICES. Surgeon billing codes linked to ankle fracture diagnostic codes were used to identify patients undergoing surgery for ankle fracture. The data sources and billing codes have been described in detail previously in the Appendix to a study by Pincus and colleagues.[8] Our study design is depicted in Figure 1. The Research Ethics Board at Sunnybrook Health Sciences Centre approved our study protocol.

Cohort

The study population has been described previously.[8] We chose to study ankle fractures because they are common injuries and their surgical management is typically performed in a nonelective setting. Patients older than 16 years undergoing isolated ankle open reduction and internal fixation (ORIF) in Ontario between Jan. 1, 1994, and Dec. 1, 2011, were eligible for inclusion. We excluded individuals who were not Ontario residents, were younger than 16 years, and had tibial plafond or bilateral ankle fractures. The beginning of the study period was selected to allow up to 2 years' look-back for patient comorbidity score calculation and identification of tibial plafond fractures in the administrative databases that began data capture in 1992. Follow-up for each patient was at least 2 years and up to a maximum of 20 years (Dec. 31, 2013).

Outcomes

We considered 6 subsequent operations as indicators of surgical complications after ankle ORIF: implant removal in isolation (i.e., without repeat ORIF, irrigation and débridement, or amputation), repeat ORIF, irrigation and débridement owing to infection, lower extremity amputation within 1 year, ankle fusion and ankle arthroplasty. Surgical complications were assessed up to the end of the study period, up to maximum of 20 years.

Main exposure

Socioeconomic deprivation was measured for each patient according to their residential location by using the "deprivation" component of the Ontario Marginalization Index (ON-MARG).[9] Neighbourhoods were sorted into quintiles, arranged from least (quintile 1) to
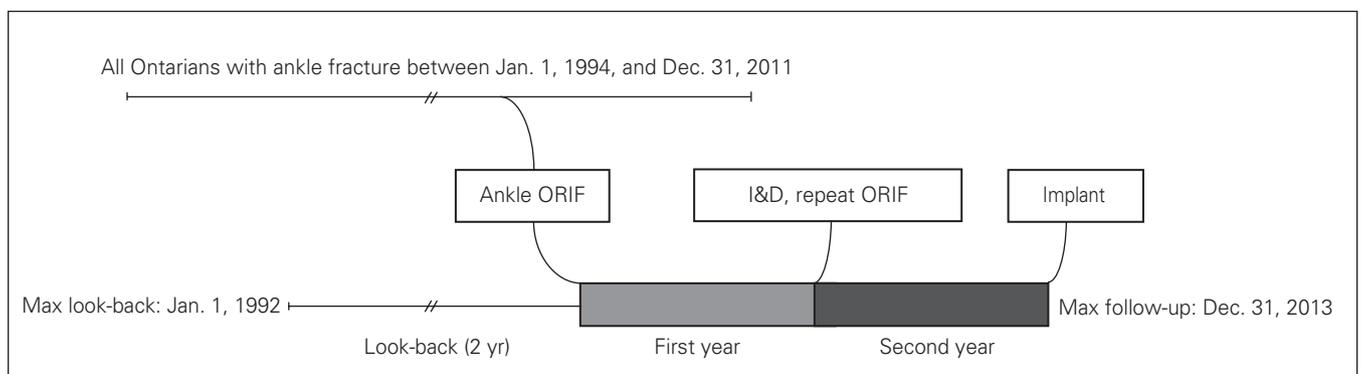

Fig. 1. Study design. I&D = irrigation and débridement; ORIF = open reduction and internal fixation.

most marginalized (quintile 5). Although there are limitations associated with quantifying socioeconomic deprivation based on address alone, the ON-MARG index takes into account several factors and has been shown to be associated with multiple health outcomes; previous research has found associations between the ON-MARG index and depression,[10] smoking,[11] alcohol consumption[12] and body mass index.[13]

Covariates

We considered several patient, provider and surgical factors previously suggested to increase complication rates after ankle ORIF.[14,15] Age and sex were analyzed as continuous and categorical variables, respectively. Comorbidities listed on hospital discharge abstracts in the 3 years before the index fixation procedure were categorized according to both the Charlson Comorbidity Index[16] and Collapsed Aggregate Diagnosis Groups (CADGs).[17] Previously validated algorithms identified patients with diabetes,[18] hypertension[19] and frailty[17] at the time of their index procedure.

Index surgeon-related factors were assigned at patient entry into the cohort. These included surgeon experience (years since their Canadian orthopedic certification) and surgeon volume (the number of ankle ORIF procedures performed in the year preceding the index event). Surgeon volume was categorized by quintile. Index hospitals were categorized as either academic or nonacademic on the basis of their membership in the Council of Academic Hospitals of Ontario (www.cahohospitals.com). Surgical covariates identified using ICD-10 diagnosis codes and Ontario Health Insurance Plan (OHIP) billing codes included the presence of an open fracture, fracture–dislocation, and single-malleolar versus bi- and trimalleolar fractures. Finally, we categorized length of stay (LOS) as day surgery, 1-night stay, or > 1-night stay.

Statistical analysis

Descriptive statistics of baseline characteristics were calculated for the entire cohort and stratified by the presence of reoperation. These statstics include medians with interquartile ranges (IQRs) and proportions as appropriate. Unadjusted comparisons by deprivation status were made using Kruskal–Wallis and χ^2 tests. Multivariable logistic regression models were used to assess the association between deprivation and implant removal, repeat ORIF, irrigation and débridement owing to infection, and amputation. Multivariable Cox proportional hazards (CPH) models were used to assess the association between deprivation and ankle fusion and ankle arthroplasty. Censoring for the CPH models occurred on death, emigration, loss of valid health care

coverage, or the end of the follow-up period — whichever occurred first. Covariates included in each multivariable model were age, sex, comborbidity index, frailty, diabetes, LOS, surgeon experience and volume, hospital academic status, fracture–dislocation and open fracture. All analyses were performed using SAS software (version 9.3 and SAS EG 6.1, SAS Institute), and the type I error probability was set to 0.05.

RESULTS

Baseline characteristics by deprivation

After exclusions, we identified 45 444 patients who underwent isolated ankle ORIF in Ontario during the study period (Fig. 2). Patients in the most deprived quintile had a significantly higher prevalence of diabetes and hypertension, higher CADG scores, and younger age (Table 1). Deprivation was also associated with longer hospital stays. Hospital LOS longer than 1 day occurred in 70.8% of patients in the most deprived quintile compared with 64.5% in the least deprived quintile ($p < 0.001$). Deprivation was not associated with sex, frailty, or a diagnosis of open fracture or ankle dislocation. Given the large sample size, the Deyo–Charlson scores, surgeon volume and experience, and hospital status reached statistical significance, but were unlikely to be clinically important factors.

Unadjusted outcomes by deprivation

The unadjusted outcomes by deprivation quintile are shown in Table 2. Deprivation was associated with an increased prevalence of irrigation and débridement for presumed infection (0.5% for quintile 5 v. 0.2% for quintile 1, $p = 0.006$) and amputation (0.2% for quintile 5 v. 0.1% for quintile 2, $p = 0.028$). Socially privileged patients were more likely to undergo hardware removal (19.6% for quintile 1 v. 17.1% for quintile 5, $p < 0.001$). Repeat ORIF was calculated separately for single-malleolar and bi- or trimalleolar ankle fractures. There was no correlation between marginalization and subsequent revision ORIF, ankle fusion, or ankle arthroplasty.

Adjusted outcomes by deprivation

Deprivation was associated with an increased risk of requiring irrigation and débridement for infection (quintile 5 v. quintile 1: odds ratio [OR] 2.14, 95% confidence interval [CI] 1.25–3.67; Fig. 3). It was also more common for patients in quintile 4 than those in quintile 1 to require amputation (OR 3.56, 95% CI 1.01–12.4). Deprived patients were more likely to undergo a subsequent ankle fusion (hazard ratio [HR] 1.21, 95% CI 0.80–1.85) and less likely to undergo an ankle arthroplasty (HR
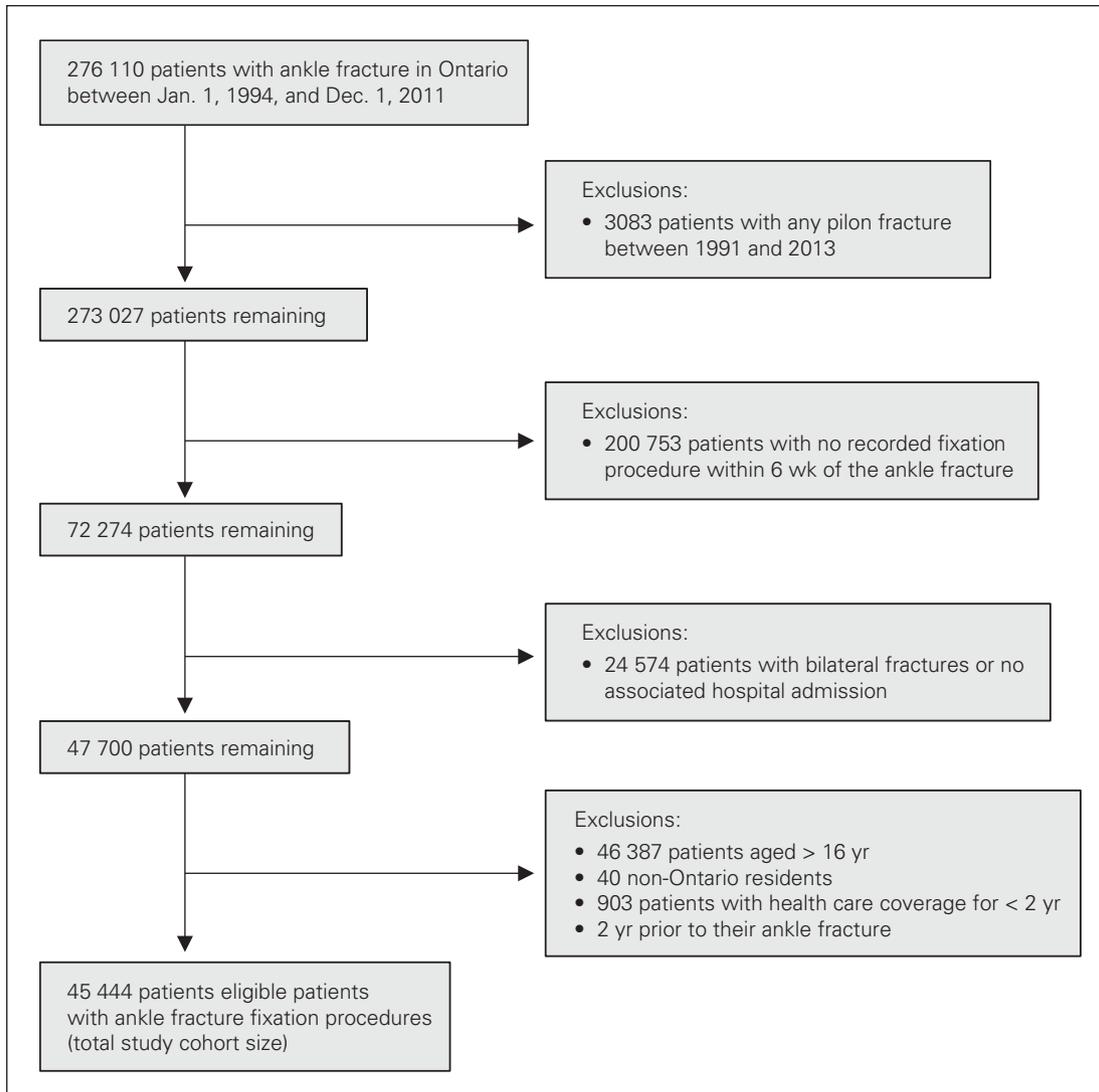
Fig. 2. Selection of patients for inclusion in the study.

0.49, 95% CI 0.22–1.07) than patients in the lowest deprivation quintile, although the hazard ratios did not reach statistical significance.

DISCUSSION

We found a significant difference between the most and least deprived patients with regard to early repeat surgery, including irrigation and débridement for infection ($p = 0.006$) and amputation ($p = 0.028$). However, the overall risk of these complications for socially deprived patients was still low (0.5% and 0.2%, respectively). Our results suggest that while more deprived patients had a statistically significant increase in the risk of an infection, the overall occurrance was uncommon. Therefore, the purported risk of infection or amputation should not preclude a socially deprived patient from operative management

of an unstable ankle fracture. Similar to what has been reported previously in the literature on hip fractures,[7] our data also support the existence of some inequalities in provision of care for more deprived patients. More deprived patients were less likely to undergo removal of hardware; the reason is unclear, but may reflect a lack of follow-up for more deprived patients or a reluctance among surgeons to offer those patients a second surgery. We also noted trends in long-term data favouring ankle arthrodesis over ankle arthroplasty, but this finding did not reach statistical significance.

Implications

There are several practice interventions that may help improve care for marginalized patients and warrant further investigation.

1. Development of supportive housing/respite facilities for discharge of patients without secure housing. Most homeless patients are discharged to shelters or the street, which has a negative impact on postoperative care. Creating a secure housing facility to allow a safer environment in which to recuperate may decrease the mental and physical stresses of homeless patients.[1,20]

2. Fracture clinic screening program. A previous study found that homeless patients had more emergency department visits and fewer orthopedic clinic follow-up visits than nonhomeless patients.[3] A comprehensive screening program similar to those used in elderly patients with fragility fractures[21] may improve follow-up in the outpatient setting and reduce the risk of poorer clinical outcomes for marginalized patients. Screening may allow for increased use of outreach programs, connecting to social workers and community aid workers, ensuring safe discharge destinations, adhering to best practices and clinical practice guidelines, and encouraging close follow-up in the fracture clinic.[22]

3. Access to multidisciplinary clinics for follow-up of their fractures. Such clinics would give patients access to showers, foot and skin care, mental health services, substance abuse services, primary care, and adequate shoes/socks during their orthopedic assessments. The assertive community treatment model may improve care and decrease hospital admission.[23,24]

4. Prolonged period of protected immobilization and non–weight bearing. Early weight bearing on fractured limbs can contribute to nonunion and malunion. A plan for prolonged protection of weight bearing, like in patients with diabetes,[25] may be beneficial for homeless patients with fractures.

5. Test alternative operative methods. Alternative surgical techniques include meticulous soft tissue handling, increased rigidity of fixation, use of locking plates, multiple tetracortical fibula-to-tibia screw fixation, percutaneous fixation, or primary joint fusion.[25]

An initial short-term recommendation is to leverage existing services in mental health, addictions management, and community agencies to create "homeless navigators." These navigators would support community partnerships to ensure safe discharge and timely follow-up for patients with no fixed address. Additionally, in the short-term, standards of care should be created for institutions who care for a high volume of homeless or marginalized individuals. The aim would be to minimize the risk of complications by standardizing care, including prolonged immobilization, more frequent wound

Table 1. Baseline characteristics by level of deprivation						
	Group; no. (%) or median [IQR]					
Characteristic	Quintile 1 (n = 8520)	Quintile 2 (n = 8501)	Quintile 3 (n = 9073)	Quintile 4 (n = 9034)	Quintile 5 (n = 9158)	p value
Age, yr	49 [35–61]	49 [36–62]	49 [35–63]	49 [35–63]	47 [34–61]	< 0.001
Sex						0.449
Female	5,037 (59.1)	5,047 (59.4)	5,379 (59.3)	5,310 (58.8)	5,325 (58.1)	
Male	3,483 (40.9)	3,454 (40.6)	3,694 (40.7)	3,724 (41.2)	3,833 (41.9)	
Deyo–Charlson score	0 [0–0]	0 [0–0]	0 [0–0]	0 [0–0]	0 [0–0]	< 0.001
CADG score						< 0.001
0–4	4952 (58.1)	4831 (56.8)	5178 (57.1)	5076 (56.2)	5015 (54.8)	
5–8	3486 (40.9)	3583 (42.1)	3786 (41.7)	3863 (42.8)	4021 (43.9)	
9–12	82 (1.0)	87 (1.0)	109 (1.2)	95 (1.1)	122 (1.3)	
Frailty	1633 (19.2)	1664 (19.6)	1704 (18.8)	1766 (19.5)	1841 (20.1)	0.226
Hypertension	2212 (26.0)	2324 (27.3)	2557 (28.2)	2570 (28.4)	2556 (27.9)	0.002
Diabetes	744 (8.7)	832 (9.8)	940 (10.4)	978 (10.8)	1107 (12.1)	< 0.001
Length of stay						< 0.001
Day surgery	1364 (16.0)	1298 (15.3)	1354 (14.9)	1237 (13.7)	1172 (12.8)	
1 night	1658 (19.5)	1627 (19.1)	1680 (18.5)	1679 (18.6)	1498 (16.4)	
> 1 night	5498 (64.5)	5575 (65.6)	6039 (66.6)	6118 (67.7)	6488 (70.8)	
Surgeon volume (ankle fracture cases in the prior year)	14 [9–20]	15 [10–21]	15 [10–22]	15 [10–22]	14 [9–21]	< 0.001
Surgeon experience, yr	11 [5–20]	12 [5–21]	12 [5–21]	11 [5–20]	12 [6–21]	0.001
Hospital status						< 0.001
Teaching	1573 (18.5)	1269 (14.9)	1297 (14.3)	1388 (15.4)	1610 (17.6)	
Non-teaching	6947 (81.5)	7232 (85.1%)	7776 (85.7)	7646 (84.6)	7548 (82.4)	
Ankle dislocation	830 (9.7)	774 (9.1)	815 (9.0)	841 (9.3)	770 (8.4)	0.038
Open fracture	209 (2.5)	238 (2.8)	226 (2.5)	260 (2.9)	256 (2.8)	0.267
CADG= Collapsed Aggregate Diagnosis Groups; IQR = interquartile range.						

Table 2. Outcomes by level of deprivation

Variable	Group; no. (%)					
	Quintile 1 (n = 8520)	Quintile 2 (n = 8501)	Quintile 3 (n = 9073)	Quintile 4 (n = 9034)	Quintile 5 (n = 9158)	p value
Repeat of index event (1+ mal)						0.37
No	8374 (98.3)	8339 (98.1)	8915 (98.3)	8860 (98.1)	8956 (97.8)	
Yes	34 (0.4)	42 (0.5)	36 (0.4)	42 (0.5)	43 (0.5)	
Missing (censored)	112 (1.3)	120 (1.4)	122 (1.3)	132 (1.5)	159 (1.7)	
Repeat of index event (2+ mal)						0.081
No	8370 (98.2)	8339 (98.1)	8920 (98.3)	8857 (98.0)	8945 (97.7)	
Yes	38 (0.4)	43 (0.5)	31 (0.3)	47 (0.5)	56 (0.6)	
Missing (censored)	112 (1.3)	119 (1.4)	122 (1.3)	130 (1.4)	157 (1.7)	
Removal of hardware						< 0.001
No	6340 (74.4)	6390 (75.2)	6899 (76.0)	6861 (75.9)	6955 (75.9)	
Yes	1671 (19.6)	1581 (18.6)	1636 (18.0)	1600 (17.7)	1565 (17.1)	
Missing (censored)	509 (6.0)	530 (6.2)	538 (5.9)	573 (6.3)	638 (7.0)	
Irrigation and débridement for presumed infection						0.006
No	8389 (98.5)	8345 (98.2)	8899 (98.1)	8856 (98.0)	8953 (97.8)	
Yes	19 (0.2)	36 (0.4)	52 (0.6)	46 (0.5)	46 (0.5)	
Missing (censored)	112 (1.3)	120 (1.4)	122 (1.3)	132 (1.5)	159 (1.7)	
Amputation						0.028
No	8406 (98.7)	8374 (98.5)	8946 (98.6)	8888 (98.4)	8986 (98.1)	
Yes	NR*	8 (0.1)	7 (0.1)	15 (0.2)	14 (0.2)	
Missing (censored)	NR*	119 (1.4)	120 (1.3)	131 (1.5)	158 (1.7)	
Ankle fusion						0.21
Events	37 (0.4)	43 (0.5)	41 (0.5)	59 (0.7)	54 (0.6)	
Censored	8483 (99.6)	8458 (99.5)	9032 (99.5)	8975 (99.3)	9104 (99.4)	
Ankle arthroplasty						0.416
Events	18 (0.2)	13 (0.2)	16 (0.2)	11 (0.1)	10 (0.1)	
Censored	8502 (99.8)	8488 (99.8)	9057 (99.8)	9023 (99.9)	9148 (99.9)	

NR = not reportable.
*Not reportable because numbers ≤ 5 are repressed in accordance with ICES guidelines.

checks, and optimizing nutritional status. Early identification of these patients will assist in adequate discharge planning and ensuring that patients receive timely follow-up.

Limitations

The population health data available through OHIP billing codes are limited in their ability to identify detailed injury and surgical predictors of reoperation. These predictors include the complexity of the initial fracture, the surgical technique used and the method of internal fixation. The details regarding postoperative management are also unavailable. However, a strength of this study is the ability of our public health care system to track patients up to 2 years postoperatively, even if they are lost to follow-up from their original surgeon, as long as they continued to be treated in Ontario and maintained their OHIP status. This is of particular relevance to tracking population-based outcomes in socioeconomically deprived patients.

It is also important to emphasize that our study focused on intermediate-term reoperation following ankle ORIF. We did not consider other adverse outcomes, such as wound complications treated nonsurgically, that may be clinically important in this population. Future work at the population level is also required to examine the outcomes of ankle fractures treated conservatively and whether surgeons avoid offering operative management to socially deprived patients. This may be best investigated using other study designs, such as qualitative studies, to assess potential surgeon bias toward socially deprived patients.

CONCLUSION

Marginalized patients are at increased risk of infection and amputation following surgery for ankle fractures. Socioeconomically advantaged patients are more likely to undergo removal of hardware. However, repeat irrigation and débridement and amputation were uncommon complications for both marginalized and nonmarginalized patients. Socioeconomic deprivation should not prohibit

marginalized patients from receiving surgery for ankle fractures, but a high level of surveillance is required to identify and mitigate potential complications. Future pro-spective research should focus on the reasons for higher complication rates in marginalized patients and on the modifiable risk factors that could minimize complications.
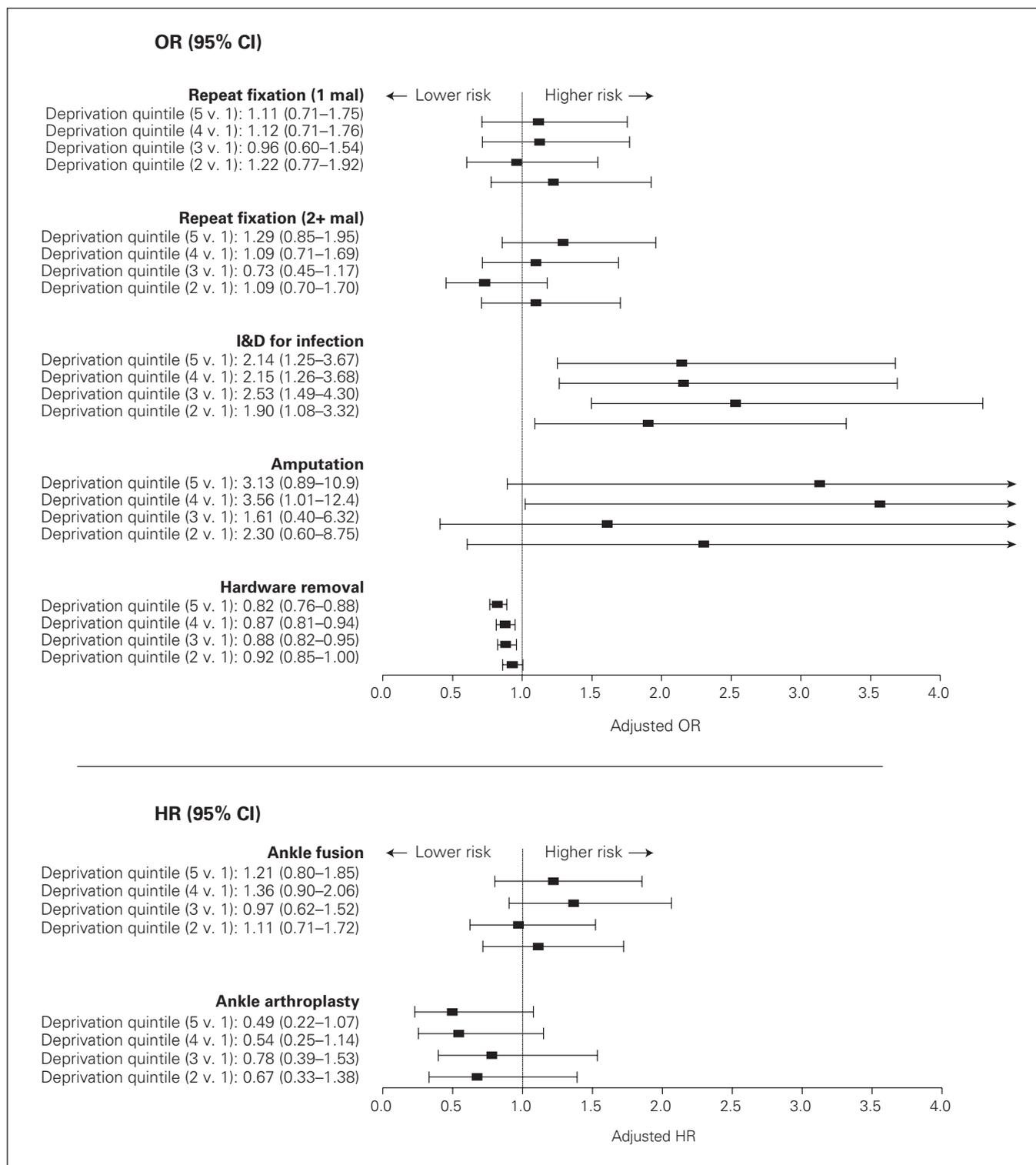
OR (95% CI)

Repeat fixation (1 mal) ← Lower risk | Higher risk →
Deprivation quintile (5 v. 1): 1.11 (0.71–1.75)
Deprivation quintile (4 v. 1): 1.12 (0.71–1.76)
Deprivation quintile (3 v. 1): 0.96 (0.60–1.54)
Deprivation quintile (2 v. 1): 1.22 (0.77–1.92)

Repeat fixation (2+ mal)
Deprivation quintile (5 v. 1): 1.29 (0.85–1.95)
Deprivation quintile (4 v. 1): 1.09 (0.71–1.69)
Deprivation quintile (3 v. 1): 0.73 (0.45–1.17)
Deprivation quintile (2 v. 1): 1.09 (0.70–1.70)

I&D for infection
Deprivation quintile (5 v. 1): 2.14 (1.25–3.67)
Deprivation quintile (4 v. 1): 2.15 (1.26–3.68)
Deprivation quintile (3 v. 1): 2.53 (1.49–4.30)
Deprivation quintile (2 v. 1): 1.90 (1.08–3.32)

Amputation
Deprivation quintile (5 v. 1): 3.13 (0.89–10.9)
Deprivation quintile (4 v. 1): 3.56 (1.01–12.4)
Deprivation quintile (3 v. 1): 1.61 (0.40–6.32)
Deprivation quintile (2 v. 1): 2.30 (0.60–8.75)

Hardware removal
Deprivation quintile (5 v. 1): 0.82 (0.76–0.88)
Deprivation quintile (4 v. 1): 0.87 (0.81–0.94)
Deprivation quintile (3 v. 1): 0.88 (0.82–0.95)
Deprivation quintile (2 v. 1): 0.92 (0.85–1.00)

Adjusted OR

HR (95% CI)

Ankle fusion ← Lower risk | Higher risk →
Deprivation quintile (5 v. 1): 1.21 (0.80–1.85)
Deprivation quintile (4 v. 1): 1.36 (0.90–2.06)
Deprivation quintile (3 v. 1): 0.97 (0.62–1.52)
Deprivation quintile (2 v. 1): 1.11 (0.71–1.72)

Ankle arthroplasty
Deprivation quintile (5 v. 1): 0.49 (0.22–1.07)
Deprivation quintile (4 v. 1): 0.54 (0.25–1.14)
Deprivation quintile (3 v. 1): 0.78 (0.39–1.53)
Deprivation quintile (2 v. 1): 0.67 (0.33–1.38)

Adjusted HR

Fig. 3. Multivariable logistic regression and Cox proportional hazards models relating socioeconomic deprivation to surgical compli-cations. Covariates included in each multivariable model were age, sex, Deyo–Charlson index, frailty, diabetes, length of stay (LOS), surgeon experience and volume, hospital academic status, fracture–dislocation, and open fracture. Adjusted odds ratios (ORs) and hazard ratios (HRs) are reported with 95% confidence intervals (CI). I&D = irrigation and débridement.

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